Transmission and Distribution Losses in GEB System corresponding to 2000-01

Final report

Prepared for **Gujarat Electricity Board**

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Executive summary

Introduction

The work relating to realistic assessment of Transmission and Distribution losses as well as to estimate the agriculture consumption in GEB system was awarded by GEB to TERI in November, 2000. These estimates are based on the identified sample size of two EHV grid substations for transmission and forty-four 11/22 kV feeders for distribution losses. In order to have realistic assessment and analysis of losses in the distribution system, it was proposed by TERI that GEB should install digital meters at least at all the Distribution Transformers (DTs) on the identified forty four 11/22 kV feeders .It was decided during the meeting held at TERI on 6th September 2000, that the zero date for the study will be the date of confirmation from GEB regarding installation of digital meters at all the Distribution Centers of the identified feeders at least in one zone of the state. The meter installation work in North zone could only be completed by GEB by April 2001. Accordingly the real work for estimation of losses in distribution network started in April 2001. The meter installation work on all the DTs of the balanced identified feeders could be completed by GEB only by the end of November, 2001. The study was completed by June 2002 and the draft final report submitted to GEB on 12th July 2002.

The **First Interim Report** covering mainly the Estimation of the Total and disaggregated (Technical & Commercial) T&D Losses in the EHT (66 KV and above voltage) transmission system in GEB has already been submitted to GEB during **August 2001.** The results of First Interim Report were discussed with the concerned officers of GEB and they were satisfied with the results of the study.

The **Second Interim Report** covering the estimation of Technical, Commercial and Total Losses of the **Distribution System** based on the results and analysis of a sample size of fourteen 11 kV feeders of various categories located in the **North Zone** of Gujarat was submitted to GEB in **February, 2002.** The preliminary results and analysis of the above-mentioned study were also presented by TERI and discussed during the First **Review Committee meeting** held at GEB, VIP Guest House at Sabarmati, Ahmedabad on **15th February, 2002.**

Third interim report covering the results and analysis of the **Distribution System** based on a sample size of eight 11 kV feeders of various categories located in **Central zone** and seven 11 kV feeders of various categories located in the **South Zone** of Gujarat was submitted to GEB in the first week of May 2002.

The results and analysis of the **Distribution System** for balance thirteen 11 kv feeders of various categories located in **West Zone I & II** where the final measurements were completed during May, 2002, has now been analysed and are covered in the **present report**.

This final Report covers the modifications / comments on the three Interim Reports, and the draft final report received during discussions / presentations to the concerned GEB officers as well as in the review committee meetings.

Scope of work

As per the T.O.R., the scope of the study was as follows: -

1. To estimate the **total T&D losses** in each Zone as well as in the GEB system corresponding to the year 2000-01 based **on sample size of:** -
   (a) **Two** representative EHV grid sub-stations for **Transmission Losses.**
   (b) **Forty four** representative urban, rural and industrial feeders for **Distribution losses.**
2. Estimation of **agricultural consumption** in the State.

Methodology

Methodology for Transmission System (66 kV and above)

The procedure of estimating T&D losses in a power system consists of estimating total Energy losses and subsequent bifurcation of these losses into technical and commercial losses.

Estimation of total Energy losses

The **Total Annual Energy Losses** for the two selected EHV Grid Sub-Stations was calculated based on the log sheet details of the energy sent and energy received at all the metering points of the identified sample size up to secondary side of 66/22/11 kV transformers during the year 2000 - 01. Applying the correction factor based on the calibration of the Panel Meters, the annual energy measurements both for energy sent out and energy received were modified.

The Annual Energy Loss in the system was worked out based on the total energy input to the sample minus total energy sent out / exported from the sample corresponding to the various scenarios' considered for the year 2000 - 01.

Estimation of Technical Power Losses

Using the sophisticated power system software available with TERI, technical power loss in MW was calculated for the **three substations** covered in the identified sample size corresponding to **three scenarios of Load conditions.** However in order to have a more realistic estimate of the total technical Power losses at 132 kV and above voltage for the GEB system as a whole, TERI decided to simulate **all the 132 kV and above voltage system of the GEB grid** on the computer to estimate the Technical power losses corresponding to the **Annual Average peak load** conditions.

Estimation of Technical Energy Losses

The load factor and loss load factor (LLF) were computed for the identified substations from the hourly readings and empirical formulae. The **Annual Technical Energy Loss** of the system was then calculated by multiplying the Technical Power loss by the loss load factor (LLF) and number of operating hours in the year.

Estimation of Commercial Energy Losses

The difference of the total energy loss and the total technical loss would give the Commercial losses or pilferage in the system during the year 2000 – 01.

Projection of Transmission losses for the State

The total Energy Losses and the total Technical Losses as worked out from the identified EHT sample were then projected for the State based on the **connected load pattern and energy consumption.** The identified EHT sample caters to predominantly agricultural and industrial Consumers. The total connected load in GEB can be divided in to two main categories i.e Agricultural and Industrial. In order to arrive at such a categorization, all the eighteen circles of GEB were categorized in to predominantly rural and predominantly industrial circle. The percentage total and technical energy loss from the EHT samples were given due weightage according to connected load to arrive at losses at the State level.

Methodology for Distribution network (11 k V and below)

Total Energy Losses in Distribution System

The Distribution network can be categorised into HT system (11/22 kV) and LT system (400 volt) including the service line to consumer end. The Total Energy Losses in the Distribution System would thus be the sum of the HT and LT System Losses

Estimation of HT Distribution System Energy Losses

The Difference of energy sent out during a particular period from the 11 kV feeder and the sum of energy measured by all the digital meters located at DT's on the feeder including direct energy consumed by 11 kV consumers if any, during the specified period of time would give total HT energy loss for that 11 kV feeder including the distribution transformers losses. The total energy sent is collected from the log sheet details of panel meters at the substation end (during a specified period), duly corrected for calibration of meters if any.

Estimation of LT Distribution System Energy losses

The difference between the total energy sent from the DTs and the sum of billed energy of metered consumers and **estimated un-metered consumption**, if any, (during the specified period) will indicate the total energy losses in 400-V distribution feeders including the service lines.

The study period for estimating the total energy losses in HT (11/22 kV) and LT (400 V) system of a feeder was kept constant.

Total Technical Losses in Distribution System

The Technical Energy Losses in the Distribution system would be the sum of technical energy losses in the HT and LT systems.

Technical Energy loss in Distribution System

The technical Power losses (kW) in the distribution system was calculated by simulating the identified 11 kV feeders including all the 11 /0.433 kV Distribution Transformers located at the feeder, on the computer. With the help of the sophisticated software available in TERI, necessary power system studies were carried out corresponding to **average daily peak load conditions** incident on the feeder, to calculate the technical power losses in 11 kV feeder ,DTs as well as the LT network.

These Technical **power losses (kW)** in the HT Feeder was then converted to HT **Technical Energy losses** (kWh) by using the **loss load factor** and number of **operating hours** of the HT Feeder as obtained from the MRI readings during **the study period.** **The total technical Energy losses (kWh)** in each selected feeder will be the **sum** of the **HT** and **LT technical Energy losses** during the **study period** worked out as indicated above.

Commercial Energy losses in the Distribution system

The commercial Energy losses are then obtained from the difference between **the total energy losses** and the **total technical energy losses** obtained as mentioned above.

Assessment of Agricultural Consumption

Due to installation of the digital meters on all the Distribution Transformers (DT's) located on the identified 11 kV rural feeders, it was possible to get a realistic idea of Agricultural consumption. The agricultural consumption was estimated as follows

Agricultural Consumption = (Consumption shown by the Digital meter- Total LT technical energy loss)* Ag. Load/total load incident on the DT)

The net Ag. Consumption of the feeder was also cross-checked by working out a norm for Ag. Consumption /HP from DT' 's with purely Ag. Connected load. The Ag. Consumption so obtained was further compared with Ag. Consumption of Tatkal and GWRDC Consumers in the same areas.

Estimation of the Annual Energy Losses in the Zone

Based on the identified 11/22 kv feeders under **each** category i.e.Urban, Rural and Industrial, all the feeders in the zone were further sub-grouped corresponding to the number of feeders of that category in the selected sample size under that zone. The set of feeders in a particular category of the zone having theoretical technical loss matching to the technical loss worked out for any of the sample feeder under the same category were clubbed in one sub group. **The number of such sub groups in each category will be equal to the number of sample feeders under that category in the zone.**
The total energy sold from the feeders in one subgroup is then calculated from the total energy sent out by these feeders in the ratio of energy sold and energy sent out by the sample feeder in that subgroup of feeder category of the zone. The aggregate of the energy sent out in all the sub groups under each feeder category will give the total energy sent out from the zone under that feeder category. Similarly the aggregate of the projected energy consumed in the sub groups under each feeder category will give the total energy consumed in that feeder category of the zone.

The difference between the energy sent & the energy sold in each feeder category of the zone will give the **total Energy loss** of the zone under that category.

The **projected energy sold** excluding (the unmetered Ag, consumption) for the zone corresponding to the year 2000-01 was **adjusted to match the actual billed energy** of that zone for the said year. The difference between the **projected and the actual energy billed could be attributed** to the following: -

1.**Inadequate Sample size** or **Sample feeders may not be True Representative of state**

2.**Metering & Billing errors.**

3.**Agriculture Consumption estimates error.**

This difference in the **Projected Energy sold** and the **Actual billed Energy** works out to about **5 Percent** of the **Energy input** to the GEB System during the year 2000 01.The energy so projected was **adjusted** to match the **actual energy billed** as per the **figures given by Accounts wing of GEB.** It may also be pointed out that there is a difference in Energy input and billed figures as given by **Distribution Wing** and the **Accounts Wing** of GEB. This needs to be reconciled as any change in the figures of accounts wing will effect the T&D Loss estimate.

Results of Study

Transmission Losses (66 kV and above)

Total energy loss, total technical and commercial loss for the GEB System (zone wise) have been estimated from the EHTsample size after giving due weightage to the connected load pattern. Following table summarize the results for the various zones

Transmission System Losses in GEB during 2000-01

Zone	Technical Losses Percent (%)	Commercial Losses Percent (%)	Total Transmission Losses Percent (%)
South	3.2	1.1	4.3
North	3.3	0.8	4.1
Central	3.3	1.0	4.3
West 1	3.3	0.9	4.2
West 2	3.3	0.9	4.2
GEB	**3.3**	**0.9**	**4.2**

Distribution System Losses

The zone wise Distribution Losses in the GEB system with respect to total State input are given in the following Table.

Distribution losses and Ag. Consumption during 2000 -01

Item	Total Technical Energy loss	Total Commercial energy loss	Total Energy Loss	Total Agricultural Consumption MU
Base		*Total State input*		
Zone				
North	2.0%	1.2%	3.2%	6647
Central	0.9%	2.5%	3.4%	925
South	1.0%	8.8%	9.8%	919
West - I	0.8%	4.7%	5.5%	2465
West -II	0.3%	2.4%	2.7%	1881
Distribution Losses	5.0%	19.6%	24.6%	12837

T&D Losses in GEB System corresponding to year 2000-01

Item	Total Technical loss	Total Commercial loss	Total Energy Loss	Total Agricultural Consumption MU
Base			*Total State input*	
Transmission Losses	3.3%	0.9%	4.2%	
Distribution Network Losses	5.0%	19.6%	24.6%	12837
Total T&D Losses in GEB	8.3 %	20.5%	28.8%	12837

Analysis of the Results of the studies (2000 - 2001)

The analysis of the results of the study indicate that the total losses in the GEB corresponding to the year 2000 - 01 is estimated to be 28.8% comprising of 7.9% technical and 20.8% commercial losses. There is little scope of reduction of technical losses as they are well within the permissible limit. However, there is scope of reduction of commercial losses.

The analysis of the results of all the zones, it is observed that Commercial Energy losses in GEB system are very high especially in South, West and central zones. In **South** zone commercial losses are around 60 % (excluding the Losses in express feeders) whereas in **Central** zone these losses are of the order of 25 % (excluding the Losses in express feeders). The losses in the two Western zones were found to be 30 percent. These commercial energy losses are mainly due to poor metering, pilferage /theft, less effective vigilance system. GEB is incurring heavy revenue losses due to these commercial losses.

Issues and Concerns

Based on the observations made during the course of the study, it is felt that GEB needs to take corrective necessary measures in respect of the following areas

Data Management

1. Availability of correct data was found to be a major constraint. The same data collected from the different sources were found to be not matching. The log sheet details of Ampere, Volt, Energy sent and received etc. being maintained at various substations is prone to human error and provides ample opportunity for manipulation.

2. The data regarding Consumer details and their connected load etc is not available transformer wise which is a pre requisite for carrying out a realistic **Energy Audit.**

3.The data regarding connected/sanctioned load of the consumers especially in Domestic and Agricultural category is not updated. Most of the Agricultural consumers in the north zone were found to be operating on a load much higher than the sanctioned load.

Metering and Billing.

1. Almost all the Panel Meters installed at various sub stations were found to be of Electro- mechanic type which normally become slow with time and require regular calibration which is not carried out at present.

2. The CT ratio of meters at some of the locations were found to be high, thereby resulting in a multiplying factor of even 4000 leading to higher error in meter measurements.
3. At present, meters are not provided on the Distribution Transformers, which is a pre-requisite to bifurcate the HT and LT Losses in the Distribution System as well as to identify high loss areas.

4. Presently the billing process in GEB is subdivision wise, and there is a significant time gap between the meter readings of adjacent consumers on the same feeder. This introduces the error in the energy accounting in the absence of a reliable data.

Commercial Losses

1. Commercial losses in GEB system are very high especially in South, Central and West Zones. In South Zone commercial losses are around 30 % .In West Zone these losses are of the order of about 25 % whereas in Central zone these losses are of the order of about 20 % These commercial which are mainly due to poor metering, theft/pilferage, less effective vigilance system.. Tackling the problem of commercial losses may be difficult but not impossible and needs a strong will to do that. Further Direct hooking at 11 kV voltage level is also prevalent in West Zone.
2. At many places in North Zone, consumers were found to be operating even during the two-phase supply with the help of suitable Capacitors.

Recommendations

The following steps to curb/reduce the level of commercial losses in the system are suggested: -

1. Replacement of LT lines emanating from all the distribution transformers, here LT losses are very high, **by Ariel Bunched Conductor** in a phased manner.
2. Domestic consumers having high consumption may be provided with **high precision digital meters.**
3. Periodic and surprise **checking of the load** of consumers having high consumption at least once a year.
4. Design an appropriate **incentive for the GEB employs** who contributes significantly in curbing the theft and in commercial loss reduction.
5. GEB should have separate **Distribution system planning wing** for micro level planning at circle level. The planning wing should have adequate facility in terms of software, computer support and accurate data about the network and load growth.
6. GEB should replace all the electromechanical meter of high CT/PT ratio with **high precision digital meters** and low multiplying factor in a phased manner.
7. GEB should create a core group at divisional level to be responsible to carry out Energy Audit, calibration of meters, replacement of meters and their proper maintenance.
8. The number of **meter testing labs** should be increased at least. one for each circle
9. All the Distribution transformers in the high loss areas should be replaced by **Integrated type (with inbuilt meter) and /or amorphous core type transformers**
10. Periodic **Energy Audit** is suggested at divisional level on regular basis.

1

Introduction

Background

Transmission and distribution system is an integral and important part of the electricity supply system. However, in many states, it has generally been neglected and has not received the necessary investment and attention. Experience in many parts of the world demonstrates that it is possible to reduce the Transmission and Distribution losses in a reasonably short period of time and that such investments have a high internal rate of return.

In GEB, the reported T&D losses are of the order of 18-20%. However, these figures are based on theoretical calculations and no study has been done to estimate the actual level of losses. Due to the fact that energy consumed by un-metered agricultural consumers might have been estimated on the higher side to understate the level of losses.

The Government of Gujarat has initiated a reform programme under the sponsorship of the Asian Development Bank. The Gujarat Govt. has also established Gujarat Electricity Regulatory Commission, an apex body to regulate the functioning of the electricity industry and to balance the interest of different players and the consumers. The G.E.R.C has also been vested with the powers to set the electricity tariff for bulk as well as retail supply to the consumers in the State of Gujarat.

In view of the above, GEB in their letter dated 13th July 2000 requested TERI to submit a proposal to conduct a T&D Loss study for the state. Considering the urgency of the problem, TERI submitted a proposal to carry out an estimate of T&D Losses of the GEB system based on a sample comprising of two feeders of each category in each of the five zones i.e. total of thirty LT feeders. In turn GEB suggested that at least 61 feeders should be considered for the study in order to have a realistic estimate of the losses. However TERI felt that to carry out a study on the sample size of 61 feeders was not feasible in the given time frame of work and the available resources. Accordingly TERI requested the officials from GEB and GERC to a presentation on T&D Loss Estimation Study for GEB regarding the scope, methodology, time schedule, etc, in Delhi on 6'Th September 2000. Mr. R.K Sharma (Member GERC), Mr. P. N. Uphadhya (Chief Engineer RE GEB) and TERI officials attended this meeting. **(Minutes of the meeting have been attached in Volume II)** In this meeting it was decided that total number of feeders to be studied should be at least about 1% of the total feeders and more emphasis be laid on agricultural feeders in order to assess the agriculture consumption in the state most of which is presently unmetered. Accordingly forty-four 11kv feeders were identified from all categories. It was also decided that feeder's selection should be done jointly by TERI and GEB.

In view of the above, GEB in a letter dated 25th November. 2000 awarded to TERI the project to conduct realistic assessment of T&D losses in the GEB system corresponding to the year 2000 - 2001 based on a sample of two EHV Substations and Forty Four 11/22 kV feeders.

Scope of work

The focus of the project is to estimate the total energy losses in HT and LT system as well as agricultural consumption of the state based on sample size of: -

1. Two representative EHV grid sub-stations for HT (11 kV and above) Losses.
2. Representative urban, rural and industrial feeders in each of the five Electrical Zones of the state for distribution losses (Maximum of 44 feeders including 4 EHT and 4 HT feeders).
3. Estimation of agricultural consumption in each zone and the State as a whole.

During the site visit to **Vav EHT** substation, it was observed that this 220 kV substation is supplying bulk of the power mainly to Surat Electricity Co. a Licensee of the G E Board. Further most of the 66KV substations under the administrative control of 220 kV Vav s/s were not being supplied from Vav substation. In view of this it was suggested to GEB by TERI that another EHT Ichhapore substation be also considered as a representative sample for meeting the demand of the Industrial consumers. Accordingly, the estimation of the EHT losses is based on the study **of three EHT Substations** and not on two EHT substations as originally envisaged in the scope of works.

2

Approach for T&D estimation

Selection of sample size

Three EHV sub-stations for the purpose of total and dis-aggregated transmission energy losses at voltage level of 66 kV and above and an aggregate of forty-four 11 kV feeders including 4 EHT and 4 HT feeders for distribution energy losses were identified jointly by GEB and TERI.

Criteria for selection

The criteria adopted for selection of the EHV Grid sub-stations and forty -four 11 kV feeders was as follows: -

EHV Grid sub-stations

Agriculture and Industrial energy consumption forms a major share of the total energy consumption in the GEB. Accordingly, two EHV sub-stations one from south Gujarat Area predominantly catering to Industrial consumers and the other one from North Gujarat Area dominated by the agricultural consumption were identified. Based on this, **Vav** 220/66 kV Grid sub-station in South Gujarat and **Mehsana** 220/132/66 kV Grid sub-station in North Gujarat were selected. All the associated 132 kV and 66 kV sub-stations along with the associated transmission lines being fed from the above two 220 kV Grid Substations are included in the sample size for the purpose of technical loss study for computer simulation.

As indicated in Chapter I, during the field visit to Vav, it was observed that, out of the eleven 66 kV sub-stations covered under Vav Grid Station only Kadodra, Palsana and Bardoli are supplied power from Vav and the remaining eight sub-stations were not fed from the Vav Grid sub-station. Further two EHT feeders namely; SEC-C station and SEC-E station were feeding power to Surat Electric Company a private licensee, which did not truly represent industrial load. It was also observed that there also existed an inter-link transmission line between Vav and Icchapore 220 kV Grid sub-stations. Keeping in mind that the HWP (Heavy water plant) EHT feeder was also included in the sample, Teri decided to consider all the 66 kV sub-stations and EHT express feeders, which are being supplied power both from Vav and Ichhapore 220 kV Grid sub-stations in the sample. So that the sample truly represents an industrial sub-station in spite the fact that the Icchapore was not originally covered in the scope of work.

The details of selected 66/22/11 kV sub-stations under Vav, Ichhapore (volu 2, page 1) and Mehsana Grid sub-stations (volume 2, page 2), The single li diagram of selected sample under each Grid station are given in the volume 2 page 3, 4 and 5.

11 kV feeders

As on March 31,2000, GEB power system comprised of 4,532 distribution 22/11 kV feeders catering to the various categories of consumers including 142 EHT Consumers. As already agreed by GEB, GERC and TERI, forty-four 22/11 kV feeders (about 1% total 11 kV feeders in the state) including 25 predominantly rural feeders were identified. Category-wise details of the identified distributio feeders have been shown in Table-2.1.

Table 2.1. Category-wise details of identified distribution feeders

Category of feeders	Total number of feeders	Number of feeders selected
EHT(66kV and above)	142	2
HT (11kV and above)	295	4
Industrial	702	6
Urban	725	7
Rural	2668	25
Total	4532	44

Feeders selection criteria under each category

The two 66 kV EHT feeders were identified based on continuous power drawn from the two selected EHV grid stations.

In the case of LT, industrial, rural and urban **feeders**, the feeder under specific consumer category whose energy loss (calculated by GEB based on energy sent and energy billed at the end users) is equal to the average energy loss under the same consumer category of the respective distribution circles were identified. The circle wise and category wise details of these feeders are given in the following Table no 2.2.

Table 2.2. Circle wise details of the representative feeders in GEB

Zone	Circle	Name of feeders under each category					
		Urban	Industrial	Rural (Ag)	EHT	HT	Total
North	Mehsana	1. Rajkamal	1. Viramgaon	1. Piludara 2. B.pura 3. Madhi 4. Lakshmipura	1. ONGC	—	7
	Palanpur	—	—	5. Matu 6. Padi 7. Lukhasan 8. Majdar	—	—	4
	Himatnagar	---	—	9.Meherpura 10.Kotpur	—	—	2
	Sabarmati	---	2. GDDC	11.Rohika	—	—	2
Sub-total		1	2	11	1	—	15
South	Surat	1. Navyug	1. Randher-2 2. Feeder No. 11	—	1. HWP	1. Paraspetra	5
	Valsad	---	---	1. Rabda	—	—	1
	Baruch	---	---	2. Palej	—	2. GJ par	2
Sub-total		1	2	2	1	2	8
Central	Anand	1. Anand city-I 2. SVG	---	1. Gothaj	—	—	3
	Baroda	---	1. Ranoli	2. Bhoj	—	1. Transpeck	3
	Godhra	—	—	3. Nadisar	—	—	1
Sub-total		2	1	3	—	1	7
West-I	Rajkot	1. Mahila College 2. Bhaktinagar	1. Jambudia	1. Godhala 2. Motimard	—	1. Manibhadra	6
	Jamnagar			3. Vijarakhi	—	—	1
	Porbandar	---	---	4. Chiroda 5. Bagdu	—	—	2
				6.			
Sub-total		2	1	6	—	1	10
West-II	Bhavnagar	1. Karget	---	1. Bhandar	—	—	2
	Surendra Nagar	---	—	2. Palasan 3. Zikkhari	—	—	2
	Amreli	—	—	4. Jalia	—	—	1
Sub-total		1	—	3	—	—	4
Grand Total		7	6	25	2	4	44

Observation about EHV substation

Mehsana Grid sub-station (Agricultural dominated)

Mehsana Transmission division has eleven 66/11 kV sub-stations under its administrative control. Out of these Basana, Modhera, Jothana and Dhinoj 66/11 kV sub-stations are not being fed from 220 kV sub-station at Mehsana due to increase in load demand. Power from Mehsana is transmitted to Anjar and Deoder at 220 kV level and to Patan and Sidhpur at 132 kV respectively. Power transformation takes place at various points i.e. from 220/132, 220/66 and 132/66 kV voltage levels. Mehsana sub-station mainly caters to predominantly agricultural load with a little mix of industrial and urban domestic load. Various 66 kV lines emit from Mehsana 66 kV substation and cater the power to various areas such as Motap, Balol etc. Mehsana 66 kV system is radial in nature and flow of power is unidirectional.

Prior to March 29, 2000 Soja was the only one source for power supply to the Mehsana Grid sub-station. After interconnection of one of the Soja-Mehsana 220 kV circuit at Gandhinagar on the aforementioned date, Mehsana Grid substation receives the power from two sources i.e. Soja and Gandhinagar. Power flow is unidirectional from Soja and Gandhinagar to Mehsana. A single line diagram of 220 kV lines and down to the network of 66/11 sub-stations under Mehsana Grid station is given in volume 2 at page 3.

Vav and Icchapore Grid Sub-Station

Vav and Icchapore Grid sub-stations have five generation sources namely, KAPP (Kakarpara Atomic Power Project), Ukai TPS, Kawas (NTPC), IPP's at Reliance and Essar. In addition to these, Kribco an EHT consumer also supplies power to the GEB Grid under emergency conditions. For instance, on September 7, 2000 (for which Load flow study has been conducted), it has supplied 7 MW power to the GEB grid at 66 kV from its captive plant. The power flow on the various 220 kV feeders emanating from these generation buses is bi-directional. Vav s/s normally receives Power from KAPP, Ukai TPS, Kawas and Ichhapore Grid sub-station, where as Ichhapore receives Power from Essar, Reliance and Kawas. Four 220 kV feeders namely; Kim, Navsari, Zagadia and Talangpore emanate from Vav grid station and normally power flows from Vav. However sometimes the power flows are in the reverse direction depending on the Grid Conditions.

A single line diagram of Vav and Icchapore grid sub-stations is given in volume 2 at page 4 and 5.

Vav Grid sub-station consist of 5 nos. 220/66 kV Transformers with a capacity of 100 MVA each where as Ichhapore Grid Sub-Station has 2 nos. 220/66 kV transformers one with a capacity of 100 MVA and second with a capacity of 50 MVA. A 220 kV transmission line 42 kms long interconnects both the Grid Sub-Stations.

Data Collection

E.H.T. Network

Since the study is based on the existing system with its inherent operational problems, it is essential to have a detailed representation of the system under each identified EHV grid sub-station. Accordingly the 220 kV generating stations associated with the three identified grid substations and all the 66/22/11 kV sub-stations being fed from these three Vav, Icchapore and Mehsana grid substation have been included in the sample. The network details and system parameters were furnished by GEB, based on which the sample system has been simulated on the computer and the results of load flow analysed. These power system studies were carried out for the peak, average and valley conditions for the year 2000-2001, log sheet details, single line diagram and the technical parameters of the grid system associated with the identified EHV grid s/s were made available to the study group of TERI by the GEB Engineers. The necessary data for the period of April 2000 - March 2001, covering single line diagram, voltage conditions, peak load and other technical details/parameters of the grid system associated with the two identified EHV Grid Sub-Stations were also collected from the GEB.

Data Collection Distribution Network

Regular visits were made by TERI team to collect MRI data and other required information from field. Sample checking at the consumers end on each feeder have also been done to get the real situation about load connected, meter defect or any type of theft / pilferage etc

The meters installed by GEB at the distribution transformers of these feeders are static meters with memory of around 45 days. These meters are capable of storing half-hourly data for a given duration of time. In addition to collection of

MRI readings, the one line diagram of each feeder with all the physical details of electrical component connected to the feeders, Consumers' wise connected load, rating of each transformer and service line details were also collected by Teri.

Status of meter installation

Presently the Panel meters in the GEB system are installed up to the sending end of the 11 kV feeders. In order to have a realistic idea of system losses in the LT System, it was proposed by TERI that GEB should install digital meters atleast on all the Distribution Transformers located on the identified forty four 11-22 kV feeders for the purpose of analysis of L.T. Network. It was decided during the meeting held at TERI on 6th September 2000, that the zero date for the study will be the date of confirmation from GEB regarding installation of digital meters at all the Distribution Centers of the identified feeders at least in one zone of the state. The meter installation work on the DT's located on the identified 11 kV feeders in South and Central zones could only be completed by GEB by May, 2001. Accordingly the real work for estimation of losses in LT network started in November 2001. The LT study for total Energy losses is limited to measurements based on two billing cycles of consumers under each feeder. The meter installation work on all the identified feeders could be completed by GEB only by the end of May 2001 except on four feeders in western zone where installation work has been delayed. The panel meters installed at 11 kV feeders for all the selected 44 feeders had also to be calibrated before the start of the measurements on the LT side so that the logsheet details of the energy sent by feeders can be corrected accordingly. The energy data and other detailed information corresponding to atleast two billing cycles could be completed for all the identified feeders of by November, 2001.leaving aside the monsoon period when the agriculture consumption is lowest.

3

Methodology

Methodology

The procedure of estimating T&D losses in a power system consists of estimating total losses and subsequent bifurcation of these losses into technical and commercial losses is explained below.

Estimation of total energy losses

On analysis of the collected monthly energy data relating to energy received and sent out for the various substations corresponding to the year 2000-01 in the identified EHV sample size, it was observed that there was some mismatch between energy sent and received at most of the voltage levels for the total energy data obtained from GEB corresponding to the period from April 2000 to March 2001. On a query from the concerned officers, it was ascertained that panel meters at most of the locations have not been calibrated for the last several years inspite of the fact that calibration of panel and other associated meters in the identified sample size was a pre condition before the initiation of the studies by Teri.

The issue was taken up with the concerned officers of GEB and during a meeting held at GEB Head Quarter at Baroda, it was decided that the existing log sheet energy data would be corrected based on the results of calibration of the meters in the testing laboratory for various conditions of load and power factor.

The total energy losses for the two selected EHV Grid Sub-Stations are calculated based on the log sheet details of energy sent and energy received at all the metering points of the identified sample size up to secondary side of 66/22/11 kV transformers. The energy data has been analyzed for the FY 2000 - 01. Month wise energy sent and received for the financial year 2000-01 is given in volume 2 at page 7-14 for Mehsana grid and at page 15-28 for Vav and Icchapore grid.

Actual energy loss calculation has been analysed for three scenarios based on energy sent from generation bus to the receiving end of the 66/22/11 kV transformer secondary as well as the express feeders. The three scenarios include; energy loss before applying CF (correction factor), after applying CF and with CF and wherever individual component loss found to be incorrect/erroneous, technical loss determined from the load flow studies has been taken into consideration. These three scenarios were: -

Case 1: The total energy loss at Grid network up to 11 kV was worked out. After analyzing the data at individual segments, there was a discrepancy in data at several places and even the losses in certain elements at various levels especially at 66 kv express were found to be negative.

Case 2: After applying CF (correction factor) using panel meter test reports, at some places the data has improved and at many places though it has improved a little, but not satisfactory. The loss at certain 66 kV level was again found to be negative.

Case 3: In this case an attempt was made to replace the percentage Energy loss (-ve) at elements where the individual segmental data is found to be incorrect either at the sending end or receiving end, by converting the technical loss (power) on the individual segment determined from the Load Flow studies conducted for the said sample corresponding to average load demand as occurred in the GEB system on September 7, 2000 into energy loss by applying loss load factor.

The energy log sheet details before and after applying correction factor at various metering points in the samples is given in volume 2 page 11-13 for Mehsana grid and at page 23-28 for Vav and Icchapore grid. Total energy loss for the each element under all the above mentioned three cases for the two selected EHV substations are shown in volume 2 at page 11 (for Mehsana) and 23 (for Vav and Icchapore grid). Annexure Transmission Network (66 kV and above).

Estimation of EHT Technical loss

Using the power system software, technical power loss in MW was calculated for both the sample sizes. However in order to have a more realistic estimate of the total technical losses at 132 kV and above voltage for the GEB system as a whole, TERI decided to simulate all the 132 kV and above voltage system of the GEB grid on the computer and estimate the Technical losses corresponding to the annual peak demand as well as the average peak demand.

For estimating the Technical losses from 66 kV downwards up to the secondary side of the 22 kV or 11 kV transformers at all the 66 kV sub-stations under the identified sample, the grid systems at Vav and Ichhapore and Mehsana sub-station were simulated on the computer. The total detailed analysis for the sample size corresponding to annual peak load and average peak load are given in the Table 3.2 for Vav and Ichhapore and Mehsana Grid stations respectively.

In order to convert the power losses into energy losses, the load factor in each of the substation was worked out from the hourly reading. The loss load factor (LLF) was then calculated by using the following empirical formula:

Loss Load Factor (LLF)= $0.2 \times LF + 0.8 (LF)^2$

The computer simulation of EHV sample selected have been done for four dates based on the two peaks, valley and average load conditions, However for the purpose of estimating EHT technical losses, the power loss corresponding to the Average Peak Load conditions was considered.

The **Annual technical energy loss** of the system was calculated by multiplying the average peak power loss by the (LLF) loss load factor and number of hours in a year.

Peak and valley load conditions in GEB system

Over the 25 years (1975-76 to 1999-2000), the maximum number of times peak demand occurred in GEB system was in the month of **March** and minimum demand occurred in the month of **July**. Due to draught conditions during the last few years, the peak demand during the year 2000-01 occurred in the month of September. Since the T&D losses are proposed to be estimated for the year 2000-2001, it was decided to carry out the studies for estimating the annual Technical losses based on the average peak load conditions. The power system studies were then carried out corresponding to the average peak load for GEB. This was arrived at from monthly peak load for GEB system during the year 2000 - 01.The monthly peak load for GEB system corresponding to the year 2000 - 01 are given in the Table - 3.1 below.

Table 3.1:Monthly Peak Load Recorded in GEB System

Sl. No.	Month	Peak Recorded (MW) (Average)
1.	April,2000	6592
2.	May, 2000	6409
3.	June, 2000	6013
4.	July , 2000	5071
5.	August, 2000	5614
6.	September, 2000	6519
7.	October, 2000	6746
8.	November, 2000	6446
9.	December, 2000	6253
10.	January, 2001	6114
11.	February, 2001	6130
12.	March, 2001 (up to 14 March)	6125
	Average Monthly Peak	**6169**

On going through the daily peak load records for the GEB system, it was observed that on **7th September 2000** the GEB recorded a demand **of 6148 MW**, which was **close to the average Peak demand** of the **GEB system** during the year 2000 - 01.

The two peak months namely; March 2000, and September 2000 and a period of valley condition July 2000 have been selected for the purpose of technical loss calculation for the year 2000-2001. The maximum demand catered in GEB during the months of March and September 2000 were 6587 MW and 6519 MW respectively while the average demand on September 7th was 6169 MW whereas catering the minimum demand of 3224 MW was in the month of July 2000. Based on these demands catered in GEB's system, the following dates namely; March 29 2000, July 2nd, 2000 and September 7th & 15th, 2000 have been identified for the purpose of technical loss calculation during the current financial year 2000-2001 from Vav and Mehsana Grid systems.

Table3.2: Peak and valley load condition details at Mehsana and Vav-Icchapore Grid sub-stations.

	Date	29-Mar-00	02-Jul-00	07-Sep-00	15-Sep-00
GEB	Load condition	Peak	Valley	Average Peak	Peak (Draught)
Mehsana Grid Substation	Demand met, MW	326.78	362.28	452.21	490.5
Vav and Icchapore grid substation	Demand met, MW	708.37	626.14	668	687.26

Accordingly it was decided to estimate the technical losses corresponding to the entire scenario's indicated above. The Peak load conditions would give the **optimum value of the Technical Losses and the study corresponding** to average monthly Peak Load would indicate the annual **average technical losses**

Projection of losses for the State

The total and technical losses have been projected for the State based on the connected load pattern and energy consumption. The two selected samples cater to predominantly agricultural and industrial area. If the selected sample is perfect then the percentage loss will be same for the State. For the purpose of estimating the energy losses in the GEB system, the total connected load in GEB system is divided into two categories Agricultural and Industrial corresponding to the two sample sizes. In order to arrive at such division all the circles of GEB have been categorized into predominantly, Rural and Industrial circle. Total connected load in rural and industrial circles have been considered as agricultural and industrial load. In the case of mix load circles the agricultural and industrial load of these circles has been kept in their respective category and the other load such as domestic, commercial and railway etc. have been equally added to the agricultural load and industrial load. Table showing the categorization of all the circles in the GEB in to two main categories i.e. agricultural and industrial is given as volume 2 at page 33.

The percentage total and technical energy loss from the two samples have been given weightage according to connected load to arrive at losses at State level.

Observations from data analysis

On analysis of data collected from Vav and Ichhapore substations, the following observations are made.

- During preliminary analysis, we found that there was some data mismatch at several places of the sample size namely; the data provided on Tapi and Kribco 66 kV feeders and Reliance 220 kV feeder. However, the data on Reliance 220 kV feeder at 220 kV Icchapore s/s still has the data inconsistency (particularly for the months of April and May 2000) after rechecking from the records and using the meter correction factor.

- Due to some errors, there was discrepancy in data provided to us on individual feeders' energy sent and energy received at the respective s/s.
- At several places the data has been corrected based on the panel meters test reports.
- At Icchapore 220/66 kV s/s, transformation losses are found to be 2.4%,which are which are unacceptable at any loading conditions. Therefore, transformation losses has been calculated based on the load flow conditions on September 7, 2000 while retaining the primary energy unchanged.
- The percentage line loss at EHT feeders of Heavy Water Plant, Garden Vareli, Garden Jolwa, SEC-C station and SEC-E station were found to be negative even after applying the correction factor. Since the meters installed at the receiving end are static with high accuracy, the receiving end energy was assumed as correct, sending end energy has been calculated based on the line losses occurred on the feeders on September 7, 2000 load flow conditions.
- The energy received at 66 kV Tapi s/s is less than the energy sent out from this s/s to Udhana, SEC-A station and transformers primary. So that sending energy at Tapi s/s has been considered for calculations. Secondly, transformer secondary energy is greater than the primary energy resulting -15% transformation loss. So that, transformer primary energy has been taken into account while considering the transformation losses determined on September 7, 2000 loading conditions.
- At Variav s/s, energy received from Icchapore 66 kV line is greater than the energy sent. So that receiving energy has been calculated based on the technical line losses determined by September 7, 2000 load flow conditions. Energy sent on Velenja-Vav line at Variav s/s has kept same as per the data provided by GEB. In the absence of energy meters test reports at primary and secondary sides of 66/11 kV Transformers, energy at these points also has been calculated based on the energy received at 66 kV at Variav s/s while considering the technical transformation losses.
- At Kadodra s/s, received energy at 66 kV is less than the energy sent to the EHT feeders, Palsana 66 kV feeder and transformer primary. So that, energy sent at Kadodra s/s (at 66 kV) has been assumed as the total energy received at Kadodra from 66 kV Vav. Due to -ve losses occurring on EHT feeders, technical losses determined on these feeders has been taken into account at the sending points based on load flow calculation. Transformer primary energy has been calculated based on the load flow studies conducted corresponding to September 7, 2000.

Due to unacceptable percentage transformation losses at 66/11 kV Icchapore s/s (3.3%) and 66/11 kV Olpad s/s (6.6%) even after applying correction factor, the transformation losses has been replaced with losses based on the load flow studies corresponding to September 7, 2000 conditions similar observations were made for Mehsana grid substation. Energy mismatch at various voltage levels with negative losses in various element of sample such as 220/66 kV transformer were observed at Mehsana grid substation.

Total Energy Losses in Distribution System

The methodology for estimating the Distribution Energy Losses can be sub divided into two parts namely HT System losses(11/22KV including the 11/0.4 kV DT's) and the estimation of losses in the LT System including service lines

Total Energy Losses in HT system

The Difference of energy sent out during a particular period from the 11 kV feeder and the sum of energy measured by all the digital meters located on the feeder including direct energy consumed by 11 kV consumers if any during the specified period of time would give total energy loss for that 11 kV feeder including the distribution transformers losses. The total energy sent is collected from the log sheet details of panel meters at the substation end (During a specified period), duly corrected for calibration if any. The measurements by Digital meters installed at DT's is obtained by down loading the MRI data.

Total Energy Losses in LT system

The difference between the total energy sent from the DT and the sum of billed energy of metered consumers and estimated unmetered consumption if any during the specified period calculated (as per methodology given at assessment of Agricultural Consumption) will indicate the total energy losses in 440-volt feeders.

In the case of rural feeders where majority of the consumers are unmetered, the consumers are located very near to the DT, the total Energy losses in the 440 volt lines is either limited to service line Technical losses or assumed to be negligible for short service lines.

The study period for estimating the total energy losses in HT and LT system of a feeder is kept constant.

Total Technical Energy losses

Total technical energy loss in HT system

The technical Power losses (kW) in the distribution system have been calculated by simulating the 11 kV feeders including all the 11 /0.433 kV Distribution Transformers located at the feeder on the computer and with the help of the sophisticated software available in TERI, necessary power system studies were carried out corresponding to **average daily peak load condition** incident on the feeder to calculate the technical power losses in 11 kV feeder as well as the transformer losses at the 11/0.4 kV Distribution Transformers on the simulated feeder.

These Technical **power losses (kW)** in the HT Feeder was then converted to HT system **Technical Energy losses** (kWh) by using the **loss load factor** and number of **operation hours** of the HT Feeder as obtained from the MRI readings and average daily peak loads during **the study period.**

The loss load factor (LLF) has been calculated by using the empirical formula, LLF= 0.2 x LF + 0.8 $(LF)^2$. Where LF is the **load factor** of the feeder calculated from daily peak load curve of the HT feeder obtained from GEB.

Operating Hours of supply

The **average number of supply hours** during the period of study have been calculated by dividing the sum of energy consumption of all the DT's located on the feeder by the average of the daily peak load incident on all the DT's during the study period. Thus the **average operating hours per day** is then worked out by dividing the average operating hours by the number of days in the study period.

Table 3.3. Load factor, Loss Load Factor, hours of operation, HT system technical power & Energy loss for each feeder

North Zone

Sr. No	Feeder	Circle	Duration of Study (Days)	Load Factor (LF)	Loss Load Factor (LLF)	Hours of operation	HT system technical power Loss (kW)	HT system technical Energy Loss (kW)
Urban Feeder								
1	Rajkamal	Mehsana	128	0.64	0.455	15	193	168655
Rural Feeder								
2	Piludara	Mehsana	138	0.88	0.792	9.6	433	454121
3	Laxmipura	Mehsana	175	0.88	0.796	8.2	302	344950
4	Madhi	Mehsana	148	0.89	0.812	12.0	32	46115
5	B'Pura	Mehsana	151	0.91	0.844	8.0	53	54139
6	Katpur	Himmatnagar	162	0.90	0.828	6.0	69	55534
7	Mahepura	Himmatnagar	133	0.90	0.828	6.0	197	129958
8	Pali	Palanpur	131	0.89	0.812	8.3	90	79294
9	Matu	Palanpur	138	0.91	0.844	10.0	57	66597
10	Majadar	Palanpur	77	0.91	0.844	11.0	106	75614
11	Lukhasan	Palanpur	207	0.76	0.614	7.3	170	157986
12	Rohika	Sabarmati	172	0.58	0.380	6.6	209	90064
Industrial Feeder								
13	GDDC	Sabarmati	146	0.87	0.780	5	318	180895
14	Viramgaon	Sabarmati	116	0.42	0.228	7.7	1685	344083

Central Zone

Sr. No	Feeder	Circle	Study Duration days	Load Factor (LF)	Loss Load Factor (LLF)	Hours of operation	HT system technical power Loss (kW)	HT system technical energy Loss (kWh)
Urban Feeder								
1	Anand City 1	Anand	154	0.79	0.66	19	211	415689
2	S V G	Anand	159	0.85	0.75	16	119	230560
Rural feeder								
3	Gothaj	Anand	291	0.85	0.75	11	120	287322
4	Bhoj	Baroda	163	0.87	0.79	11	165	231942
5	Nadisar	Godhra	217	0.80	0.67	13	244	475133
Industrial Feeder								
6	Ranoli	Baroda	120	0.78	0.65	22	140	240257
7	Transpeck	Baroda	120	0.69	0.51	24	27	40050
South Zone								
Urban Feeder								
1	Navyug	Surat	133	0.83	0.72	19	172	312739
Rural Feeder								
2	Rabda	Valsad	156	0.92	0.86	17	35	80897
3	Palej	Baruch	182	0.8	0.67	16	133	255561
Industrial Feeder								
4	Amroli	Surat	350	0.68	0.51	20	45	161248
5	Feeder No. II	Surat	186	0.8	0.67	16	90	182594
6	ParasPetro	Surat	120	0.7	0.53	24	20	93206
7	GJ Apar	Baruch	120	0.8	0.67	24	65	195336

West Zone 1

Sr No	Feeder	Circle	Study Duration Days	Load Factor (LF)	Loss Load Factor(LLF)	Hours of Operation	HT system technical Power Loss (kW)	HT System Technical energy Loss (kWh)
Urban Feeder								
1	Bhaktinagar	Rajkot	360	0.75	0.60	8	172	281480
2	Mahila College	Rajkot	249	0.90	0.82	15	194	612116
Rural feeders								
3	Zikiyari	Rajkot	207	0.77	0.62	12	120	190332
4	Motimarad	Rajkot	317	0.73	0.58	6	115	127746
5	Gadhala	Rajkot	108	0.64	0.46	8	60	24406
6	Bagdu	Junagarh	305	0.62	0.44	6	211	170853
7	Chiroda	Junagarh	270	0.84	0.73	7	258	372836
8	Vijarkhi	Jamnagar	159	0.79	0.65	10	215	223744
Industrial Feeders								
9	Jambudiya	Rajkot	244	0.72	0.56	8	79	89524

West Zone 2

Sr No	Feeder	Circle	Study Duration Days	Load Factor (LF)	Loss Load Factor(LLF)	Hours of Operation	HT system technical Power Loss (kW)	HT System Technical energy Loss (kWh)
Urban Feeders								
1	Khargate	Bhavnagar	345	0.75	0.60	11.69	13	31240
Rural Feeders								
2	Palasan	S'Nagar	274	0.73	0.57	9.36	41	59694
3	Bhandar	Bhavnagar	193	0.93	0.87	10.11	235	398886
4	Jaliya	Amreli	340	0.76	0.61	4.94	92	94495

Note. All the above values are rounded off to nearest integer.

Total technical energy loss in LT system

To estimate the losses in the LT network of the system following approach have been adopted.

1. All the distribution transformers of the feeder were categorised into different groups based on the transformer kVA Capacity.
2. Under each capacity group, transformers were then categorised in to three sub categories based on the LT length on each transformer
   - Transformer with LT less network (Less than 500 meters)
   - Transformer with medium LT network (about 1 km)
   - Transformer with high LT network (about 2 kms and above)

3. Network under a randomly selected transformer from each sub category was then simulated (corresponding to daily peak average load condition as per the MRI readings during the study period) using the software to work out the LT System Technical losses in kW.
4. The LT System **technical power loss** was then converted to LT system **Technical Energy loss** by multiplying power loss with the **loss load factor** and number of **operating hours** during the study period. **The average operating hours** during the study period are worked out as per methodology described under HT energy loss.
5. **The loss load factor** (LLF) has been calculated by using the empirical formula, $LLF= 0.2 \times LF + 0.8 (LF)^2$. Where LF is the load factor of the DT calculated from the daily peak load curve as obtained from the MRI.
6. The LT System technical Energy Losses (kWh) per kW per KM were found out for each sub category group of the transformer sample for the study period.
7. These per kW per KM LT System technical energy losses (kWh) under each capacity DT group were then projected for the all the transformers covered under that capacity group.
8. The sum of the **LT technical energy losses** (kWh) of all the DT capacity groups would give the total technical Energy loss (kWh) in the LT network of the whole feeder during the period of study.

Table 3.4. Load factor, Loss Load Factor, hours of operation, LT system technical power & Energy loss for each feeder

North Zone

Sr. No	Feeder	Circle	Duration of Study (Days)	Load Factor (LF)	Loss Load Factor (LLF)	Hours of operation	LT system technical power Loss (kW)	LT system technical Energy Loss (kW)
Urban Feeder								
1	Rajkamal	Mehsana	128	0.64	0.455	15	83	72766
Rural Feeder								
2	Piludara	Mehsana	138	0.88	0.792	9.6	186	195630
3	Laxmipura	Mehsana	175	0.88	0.796	8.2	39	44896
4	Madhi	Mehsana	148	0.89	0.812	12.0	13	18837
5	B'Pura	Mehsana	151	0.91	0.844	8.0	24	24613
6	Katpur	Himmatnagar	162	0.90	0.828	6.0	78	62965
7	Mahepura	Himmatnagar	133	0.90	0.828	6.0	45	29456
8	Pali	Palanpur	131	0.89	0.812	8.3	49	43243
9	Matu	Palanpur	138	0.91	0.844	10.0	114	133313
10	Majadar	Palanpur	77	0.91	0.844	11.0	26	18607
11	Lukhasan	Palanpur	207	0.76	0.614	7.3	104	97216

12	Rohika	Sabarmati	172	0.58	0.380	6.6	57	24414
Industrial Feeder								
13	GDDC	Sabarmati	146	0.87	0.780	5	159	90285
14	Viramgaon	Sabarmati	116	0.42	0.228	7.7	31	6408

Central Zone

Urban Feeders								
1	Anand City 1	Anand	154	0.79	0.66	19	142	275028
2	S V G	Anand	159	0.85	0.75	16	66	125767
Rural Feeders								
3	Gothaj	Anand	291	0.85	0.748	11	32	76068
4	Bhoj	Baroda	163	0.866	0.784	11	30	42354
5	Nadisar	Godhra	217	0.8	0.67	13	148	280622
Industrial Feeders								
6	Ranoli	Baroda	120	0.78	0.65	22	165	283312
7	Transpeck	Baroda	120	0.69	0.51	24	0	0

South Zone

Urban Feeders								
1	Navyug	Surat	133	0.83	0.72	19	226	411029
Rural Feeders								
2	Rabda	Valsad	156	0.92	0.86	17	18	42167
3	Palej	Baruch	182	0.8	0.67	15	144	263085
Industrial Feeders								
4	Amroli	Surat	350	0.68	0.51	20	91	323873
5	Feeder No. II	Surat	186	0.8	0.67	16	77	153201
6	ParasPetro	Surat	120	0.7	0.53	24	0	0
7	GJ Apar	Baruch	120	0.8	0.67	24	0	0

West Zone 1

Sr No	Feeder	Circle	Study Duration Days	Load Factor (LF)	Loss Load Factor(LLF)	Hours of Operation	LT system technical Power Loss (kW)	LT System Technical energy Loss (kWh)
Urban Feeders								
1	Bhaktinagar	Rajkot	360	0.75	0.60	8	25	40836
2	Mahila College	Rajkot	249	0.90	0.82	15	56	177131
Rural Feeders								
3	Zikiyan	Rajkot	207	0.77	0.62	12	22	35160
4	Motimarad	Rajkot	317	0.73	0.58	6	14	16029
5	Gadhala	Rajkot	108	0.64	0.46	8	20	8065
6	Bagdu	Junagarh	305	0.62	0.44	6	58	47470
7	Chiroda	Junagarh	270	0.84	0.73	7	69	99457
8	Vijarkhi	Jamnagar	159	0.79	0.65	10	54	56248
Industrial Feeders								
9	Jambudiya	Rajkot	244	0.72	0.56	8	9	9741

West Zone 2

Sr No	Feeder	Circle	Study Duration Days	Load Factor (LF)	Loss Load Factor(LLF)	Hours of Operation	LT system technical Power Loss (kW)	LT System Technical energy Loss (kWh)
Urban Feeders								
1	Khargate	Bhavnagar	345	0.75	0.60	11.69	83	200297
Rural feeders								
2	Palasan	S'Nagar	274	0.73	0.57	9.36	17	24039
3	Bhandar	Bhavnagar	193	0.93	0.87	10.11	226	384178
4	Jaliya	Amreli	340	0.76	0.61	4.94	36	36637

Note. All the above values are rounded off to nearest integer

Total Technical Energy loss

Thus **the total technical Energy losses (kWh)** in each selected feeder will be the **sum** of the **HT** and **LT technical Energy losses** during the **study period** worked out as indicated above.

Total Commercial Energy Loss

The commercial losses are then obtained from the difference between **the total energy losses** and the **total technical energy losses** obtained as mentioned above.

Assessment of Agricultural Consumption

Due to installation of the digital meters on all the Distribution Transformers (DT's) located on the identified 11 kV rural feeders, it has been possible to get a realistic idea of Agricultural consumption. The agricultural consumption then can be obtained as follows

Agricultural Consumption = Total energy sent from DTs – (technical energy loss on 433 V line/cables between the DTs and consumers + Billed energy during the period on the DT if any) ---------------------------------(1)

The situation in south and central zone is very much different as compared to the situation in North zone. In these two zones almost all the transformers are having mixed load. If the above formula is applied for transformer with mixed load, the possibility of commercial losses being added to agricultural consumption is very high. In order to overcome this anomaly, Agriculture consumption in these Zones was calculated by following method.

Agricultural Consumption = (Consumption shown by the Digital meter- Total LT technical energy loss)*Ag. Load/total load incident on the DT)-----(2)

The net Ag. Consumption of a feeder will then be estimated by adding the Ag. Consumption of all the DT's located on that feeder. **Per HP Ag. Consumption** was then worked out by dividing the net Ag. Consumption of the feeder by the total sanctioned load on that feeder.
The net Ag. Consumption of the feeder was also estimated by another method as under

Agricultural consumption of all the DT's with purely Ag. Load was worked out by adding the MRI readings of all these DT's. The per HP Ag. Consumption for these DT's was then worked out by dividing the difference between total Ag. consumption and LT technical network loss in these DT's by the total sanctioned load.

The **per HP Ag. Consumption thus** obtained was used as a **norm** to estimate the Ag. Consumption on all the DT's feeding Ag load located on the feeder. The aggregate of Ag. Consumption of these DT's would give the total Ag. Consumption of the feeder.

However, it was observed that the difference of agricultural consumption estimated by the above two methods was not significant. In view of this only the method used for mixed load DT's was applied to estimate the agriculture consumption.

Estimation of the total energy losses in the Zone

The total 11/22 kv feeders under **each** category i.e. Urban, Rural and Industrial in the zone were further sub-grouped corresponding to the number of feeders of that category in the selected sample size under that zone. The set of feeders in a particular category of the zone having theoretical technical loss matching to the technical loss worked out for any of the sample feeder under the same category were clubbed in one sub group. The process is repeated for all the feeders under each category till the feeders in the zone are covered in any of the sub groups.

The total energy consumed / sold from the feeders in one subgroup is then calculated from the total energy sent out by these feeders in the ratio of energy consumed / sold and energy sent out by the sample feeder in that subgroup of feeder category under the zone. The aggregate of the energy sent out in all the sub groups under each feeder category will give the total energy sent out from the zone under that feeder category. Similarly the aggregate of the projected energy consumed in the sub groups under each feeder category will give the total energy consumed in that feeder category of the zone.

The **projected energy sold** excluding (the unmetered Ag, consumption) for the zone corresponding to the year 2000-01 was **adjusted to match the actual billed energy** of that zone for the said year. The difference between the **projected and the actual energy billed could be attributed** to the following: -

1.**Inadequate Sample size** or **Sample feeders may not be True Representative of state**
2.**Metering & Billing errors.**
3.**Agriculture Consumption estimates error.**

This difference in the **Projected Energy sold** and the **Actual billed Energy** works out to about. **3.5 Percent** of the **Energy input** to the GEB System during the year 2000 01.The energy so projected was **adjusted** to match the **actual energy billed** as per the **figures given by Accounts wing of GEB..** It may also be pointed out that there is a difference in Energy billed figures as given by **Distribution Wing** and the **Accounts Wing** of GEB. This needs to be reconciled as any change in the figures of accounts wing will effect the T&D Loss.

The difference between the energy sent & the energy consumed in each feeder category of the zone will give the **total losses** of the zone under that category. Subsequently the energy losses for the North Zone as given in the Second Interim report have been reworked also with the reconciled energy sale figures of account wing of GEB and the summary of the same is also covered under Chapter 4.

4

Results and analysis

Results

Vav and Icchapore Grid Sub-Station

The system that input at 220 kV and 66 kV from various sources was 4275599 MWh and 700 MWh respectively. Corresponding to this, the quantum of energy received at 220 kV and 66 kV lines and 22 kV and 11 kV transformers was 4101890 MWh while a loss of 174410 MWh. As a percentage of input, the total loss up to 11 kV in the system is calculated to be 4.3%.

The table showing total annual energy loss under on various scenarios at Vav and Ichhapore 220 kV Grid system (sample size).

Table 4.1: Total energy loss under various scenarios

	Before applying Correction Factor	After applying Correction Factor	After incorporating technical energy loss (Wherever required)
	MU	MU	MU
Total annual energy input	4284.92	4284.30	4284.30
Total annual energy out put	3932.80	3847.75	3856.95
Total annual energy export	275.11	284.74	241.80
Total annual energy loss	77.01	151.81	185.55
% Loss	1.80%	3.54%	4.33%

Mehsana Grid Substation

Mehsana grid substation, which mainly caters to the agricultural load, has 3765 MU total energy input to the system. Export of energy to the other places counted for 1516.4 MU in the FY 2000-01 and the loss mounted in the system was 4.08 %.

Table 4.2: Total annual energy loss under various scenarios at Mehsana 220 kV Grid system (Sample Size).

	Before applying Correction Factor	After applying Correction Factor	After incorporating technical energy loss (Wherever required)
	MU	MU	MU
Total annual energy input	4032.41	3991.74	3765.12
Total annual energy output	1488.82	1516.41	1516.41
Total annual energy export	2075.84	2094.95	2094.95
Total annual energy loss	467.74	380.38	153.76
% Loss	11.60%	9.53%	4.08%

Technical energy loss

Table-4.3 : Technical loss as well as actual energy loss calculation at Vav & Ichhapore 220 kV Grid system (Sample Size)

	7th Sept	29th March	15th Sept	2nd July
Power input, MW	636.53	708.37	687.26	626.15
Power loss, MW	19.55	16.02	20.712	15.43
% loss	3.07%	2.26%	3.01%	2.46%
Energy Input, MWh	4907054	5398629	4756114	4662313
Tech. Energy loss, MWh	138733.2	109475.1	119748.5	101388.2
% Loss	2.83%	2.03%	2.52%	2.17%

Note: Change in peak power loss (MW) at various Load Flow conditions is due to changes in power flows at different voltage levels such as 220 kV and 66 kV.

Mehsana Grid Sub-Station

Table-4.4: Technical loss as well as actual energy loss calculation at Mehsana 220 kV Grid system (Sample Size)

	7th Sept	29th March	15th Sept	2nd July
Power input, MW	191.39	147.76	210.88	115.55
Power loss, MW	7.00	4.28	8.31	3.55
% loss	3.658%	2.896%	3.94%	3.07%
Energy Input, MWh	1280669.72	1087263.7	1564671	685275.6
Tech. Energy loss, MWh	37895.76	27997.3284	55033.47	16277.23
% Loss	2.96%	2.58%	3.52%	2.38%

Total and Commercial losses for the two EHV grid substation

The following table summarizes the total, technical and commercial energy loss for the two-selected EHV grid substation.

Table 4.5: Total and Commercial losses for the two EHV grid substation

Loss	Mehsana Grid	Vav and Icchapore Grid
Total Energy Loss (%)	4.08%	4.33%
Total Technical Energy Loss (%)	2.96%	2.83%
Commercial Loss (%)	1.12%	1.50%

Technical and commercial losses for the Gujarat State (zone wise

Total energy loss, total technical and commercial loss for the Gujarat State and various zones have been estimation from the sample size after giving due weightage to the connected load pattern. Following table summarize the results for the various zones and the State.

Table 4.6: Results of the various zone and the state

Zone	*Total Energy*	*Technical Energy*	Commercial Energy
	%	%	%
South	4.3	3.2	1.1
North	4.1	3.3	0.8
Central	4.3	3.3	1.0
West 1	4.2	3.3	0.9
West 2	4.2	3.3	0.9
GEB	4.2	3.3	0.9

otal technical energy loss (based on total simulation of grid up to oltage level 132 kV)

In order to cross check and to confirm the accuracy, technical energy loss was also calculated by simulation the whole GEB electrical network up to 132 kV voltage level for average load condition of 7th September. Technical loss at 66 kV voltage level after giving due weightage to the percentage energy loss from two sample size was added to this in order to arrive at total technical energy loss. It was found that total energy loss up to 132 kV voltage level was 2.15 % and at 66 kV voltage level it was found to be 1.2 %. Hence total technical energy loss for GEB system is 3.3 % , this again confirms the earlier calculated percentage of technical energy loss.

Results of Distribution network (11 kV and below)

The following table summarises total energy losses and its segregation into technical and non technical losses (percentage) in the HT, LT system during the study period for the identified feeders. The absolute value of these losses and detailed calculations are summarised in Volume 2 at page 66 and 67 for distribution network north zone.

Table 4.7: North Zone

Sr. No	Feeder	Circle	HT Losses kWh			LT Losses kWh			Total Energy Losses kWh		
			Total	Tech. Loss	Comm. loss	Total	Tech. Loss	Comm. loss	Total	Tech. Loss	Comm. loss
1	2	3	4	5	6	7	8	9	10	11	12
Urban											
1	Rajkamal	Mehsana	7.3%	4.2%	3.2%	11.8%	1.8%	10.0%	19.1%	5.9%	13.1%
Rural											
2	Piludara	Mehsana	11.8%	9.6%	2.3%	5.8%	4.1%	1.6%	17.6%	13.8%	3.8%
3	Laxmipura	Mehsana	9.3%	9.3%	0.1%	3.4%	1.2%	2.2%	12.7%	10.5%	2.2%
4	Madhi	Mehsana	4.1%	2.9%	1.3%	8.4%	1.2%	7.2%	12.5%	4.0%	8.5%
5	B'Pura	Mehsana	7.3%	4.2%	3.1%	9.5%	1.9%	7.6%	16.8%	6.1%	10.7%
6	Katpur	Himmatnagar	23.9%	2.38%	21.6%	15.04%	3.57%	11.47%	38.4%	6.8%	31.7%
7	Mahepura	Himmatnagar	27.0%	6.3%	20.7%	2.1%	1.4%	0.7%	29.1%	7.7%	21.4%

1	2	3	4	5	6	7	8	9	10	11	12
8	Pali	Palanpur	4.7%	4.3%	0.4%	5.4%	2.3%	3.1%	10.1%	6.6%	3.5%
9	Matu	Palanpur	4.3%	3.3%	1.0%	13.5%	6.5%	7.0%	17.8%	9.8%	8.0%
10	Majadar	Palanpur	10.5%	4.3%	6.2%	1.3%	1.1%	0.2%	11.8%	5.4%	6.4%
11	Lukhasan	Palanpur	15.1%	4.1%	11.0%	6.93%	2.5%	4.40%	22.0%	6.6%	15.4%
12	Rohika	Sabarmati	5.8%	4.9%	0.9%	8.60%	1.32%	7.28%	14.3%	13.5%	0.90%
Industrial Feeders											
13	Viramgaon	Sabarmati	11.0%	9.0%	2.0%	13.44%	0.2%	13.27%	24.4%	9.2%	15.3%
14	GDDC	Sabarmati	4.7%	4.2%	0.4%	5.0%	2.1%	2.9%	9.7%	6.4%	3.4%

The absolute value of these losses and detailed calculations are summarised in Volume 2 at page 98 for distribution network of central and at page 124 for south zone.

Table4.8: Feeder wise Distribution ENERGY losses (Total, HT and LT) based on own base during the Study period (Sample case)

Sr. No	Feeder	Circle	HT Losses kWh			LT Losses kWh			Total Energy Losses kWh		
			Total	Technical	Commercial	Total	Technical	Commercial	Total	Technical	Commercial
Central Zone											
	Urban										
1	Anand City 1	Anand	4.5%	4.0%	0.5%	26.3%	2.7%	23.7%	30.8%	6.7%	24.2%
2	S V G	Anand	3.8%	3.4%	0.3%	31.3%	1.9%	29.5%	35.1%	5.3%	29.8%
	Rural										
3	Gothaj	Anand	7.2%	6.3%	0.9%	10.6%	1.7%	9.0%	17.8%	8.0%	9.9%
4	Bhoj	Baroda	7.2%	6.2%	0.9%	15.7%	1.1%	14.5%	22.8%	7.4%	15.5%
5	Nadisar	Godhra	13.1%	8.2%	5.0%	43.6%	4.8%	38.8%	56.7%	13.0%	43.7%
	Industrial										
6	Ranoli	Baroda	5.0%	4.1%	0.9%	16.4%	4.9%	11.6%	21.5%	9.0%	12.5%
7	Transpeck	Baroda	4.2%	3.8%	0.4%	-	-	-	4.2%	3.8%	0.4%
South Zone											
	Urban										
1	Navyug	Surat	5.9%	5.7%	0.2%	33.9%	7.5%	26.4%	39.7%	13.2%	26.6%
	Rural										
2	Rabda	Valsad	8.1%	4.2%	4.0%	13.0%	2.2%	10.8%	21.1%	6.3%	14.8%
3	Palej	Baruch	11.1%	5.1%	6.1%	13.2%	5.2%	8.0%	24.4%	10.3%	14.0%
	Industrial										
4	Amroli	Surat	1.8%	1.6%	0.2%	40.8%	3.2%	37.6%	42.6%	4.8%	37.9%
5	Feeder No. II	Surat	18.0%	2.2%	15.8%	31.6%	1.9%	29.7%	49.6%	4.1%	45.5%
	HT express										
6	ParasPetro	Surat	2.4%	2.2%	0.2%	0.0%	0.0%	0.0%	2.4%	2.2%	0.2%
7	GJ Apar	Baruch	4.2%	4.1%	0.1%	0.0%	0.0%	0.0%	4.2%	4.1%	0.1%

The absolute value of these losses and detailed calculations are summarised in Volume 2 at page 146 of distribution network west zone 1.

Table 4.9: Feeder wise Energy losses (Total, HT and LT) during the Study period (Sample case)

Sr. No	Feeder	Circle	HT Losses kWh			LT Losses kWh			Total Energy Losses kWh		
			Total	Tech. Loss	Comm. loss	Total	Tech. Loss	Comm. loss	Total	Tech. Loss	Comm. loss
Urban											
1	Bhaktinagar	Rajkot	6%	3%	2%	26%	0.2%	25.8%	32%	3.2%	28%
2	Mahila College	Rajkot	18%	6%	12%	24%	2%	22%	42%	8%	34%
Rural											
3	Zikiyan	Rajkot	8.3%	5.2%	3.1%	18.9%	1.0%	17.9%	27.2%	6.1%	21.1%
4	Motimarad	Rajkot	57%	3%	54%	2%	0.5%	1.5%	59%	3.5%	55.5%
5	Gadhala	Rajkot	26%	3%	23%	2%	1%	1%	28%	4%	24%
6	Bagdu	Junagarh	16%	3%	14%	8%	1%	7%	24%	3%	21%
7	Chiroda	Junagarh	19%	6%	13%	2%	1%	1%	21%	7%	14%
8	Vijarkhi	Jamnagar	21%	6%	15%	20%	2%	18%	41%	8%	33%
Industrial											
9	Jambudiya	Rajkot	2%	1%	1%	18%	0.8%	17.2%	20%	1.8%	18.2%

The absolute value of these losses and detailed calculations are summarised in Volume 2 at page 165 of distribution network west zone 2.

Table 4.10 West Zone 2 Feeder wise losses (Total, HT and LT) during the Study period (Sample case)

Sr. No	Feeder	Circle	HT Losses kWh			LT Losses kWh			Total Energy Losses kWh		
			Total	Tech. Loss	Comm. loss	Total	Tech. Loss	Comm. loss	Total	Tech. Loss	Comm. loss
Urban											
1	Karget	Bhavnagar	1.3%	0.5%	0.7%	43%	3.4%	39.4%	39.9%	4%	36%
Rural											
2	Palasan	Sure'nagar	24%	1%	22%	6%	0.5%	5.5%	30%	2.5%	27.5%
3	Bhandar	Bhavnagar	32%	4%	27%	8%	4%	4%	40%	9%	31%
4	Jaliya	Amreli	20%	4%	16%	2%	2%	0%	22%	6%	16%

The following table gives summary of total energy loss and its segregation in to technical and non-technical losses (Percentage) and agricultural consumption in per HP for the base year 2000-01 for the North, Central and South zones. The absolute value of these losses and detailed calculations are summarised in Volume 2 at page 76 for north zone at page 104 for central zone and at page 128 for south zone Distribution network.

Table 4.11: Category wise Distribution Energy losses for the North Zone during year 2000-01

Feeder Category	Total technical energy loss	Total commercial loss	Total energy loss	Total technical energy loss	Total commercial loss	Total energy loss
		Own Base			Zone (11 kV) input as base	
Rural	9.0%	2.2%	11.2%	6.8%	1.7%	8.4%
Urban	6.5%	20.2%	26.7%	0.5%	1.4%	1.9%
Industrial	7.8%	10.7%	18.6%	0.8%	1.1%	1.9%
HTEX	0.1%	10.3%	10.4%	0.01%	0.7%	0.8%
Total				8.1%	4.9%	13%

Table 4.12: Category wise Distribution Energy losses for the Central Zone during year 2000-01

Feeder Category	Total technical energy loss	Total commercial loss	Total energy loss	Total technical energy loss	Total commercial loss	Total energy loss
		Own Base			Zone (11 kV) input as base	
Rural	11.8%	24.9%	36.6%	5.2%	11.0%	16.2%
Urban	6.8%	29.9%	36.6%	2.4%	10.5%	12.9%
Industrial	9.2%	20.8%	30.0%	1.2%	2.8%	4.0%
HTEX	1.1%	10.4%	11.5%	0.1%	0.7%	0.8%
Total				8.9%	25.0%	33.9%

Table4.13: Category wise Distribution Energy losses for the South Zone during year 2000-01

Feeder Category	Total technical energy loss	Total commercial loss	Total energy loss	Total technical energy loss	Total commercial loss	Total energy loss
		Own Base			Zone (11 kV) input as base	
Rural	8.9%	23.6%	32.5%	2.2%	5.9%	8.1%
Urban	13.6%	65.4%	79.0%	2.2%	10.8%	13.0%
Industrial	4.7%	76.2%	80.9%	2.4%	38.4%	40.8%
HTEX	0.2%	65.7%	65.9%	0.01%	5.4%	5.5%
Total				6.8%	60.5%	67.4%

The absolute value of these losses and detailed calculations are summarised in Volume 2 at page 154 for distribution network west zone1.

Table 4.14:Category wise consumption for the West Zone 1 during year 2000-01

Category	Total technical energy loss	Total commercial loss	Total energy loss	Total technical energy loss	Total commercial loss	Total energy loss
	Own Base 11 kV input			Zone (11 kV) input as base		
Rural	5.9%	24.1%	30.0%	3.4%	13.9%	17.4%
Urban	5.7%	41.0%	46.7%	1.7%	12.2%	13.9%
Industrial	1.2%	31.9%	33.2%	0.1%	3.2%	3.4%
HTEX	0.7%	16.9%	17.6%	0.01%	0.4%	0.4%
Total				5.3%	29.8%	35.0%

The absolute value of these losses and detailed calculations are summarised in Volume 2 at page 167 for distribution network west zone 2.

Table 4.15: Category wise consumption for the West Zone2 during year 2000-01

Category	Total technical energy loss	Total commercial loss	Total energy loss	Total technical energy loss	Total commercial loss	Total energy loss
	Own Base 11 kV input			Zone (11 kV) input as base		
Rural	2.9%	26.3%	29.2%	2.1%	18.8%	20.8%
Urban	3.2%	9.2%	12.4%	0.7%	2.1%	2.8%
Industrial	1.0%	24.7%	25.8%	0.01%	1.1%	1.1%
HTEX	0.2%	11.7%	11.9%	0.01%	0.2%	0.2%
Total				2.8%	22.1%	25.0%

High Loss Area

The entire rural, urban and industrial feeders in central zone and south zone have high Distribution losses. On analysis of the various identified feeders it is observed that the total energy losses in Nadisar feeder of central zone have exceptionally high losses of 56.7 % and industrial feeder no II of south zone have high losses of the order of 49.6 %.

Projection of T&D losses and agricultural Consumption Corresponding to 2001 - 02

For estimating the T&D losses and the agricultural consumption per kW corresponding to year 2001-02 it has been assumed to be same as worked out for the year 2000-01. Total T&D losses corresponding to year 2001-02 has been worked out based on the data furnished by the GEB accounts wing.

Further it has been assumed that there is no change in percentage of losses (4.2%) in the EHT (66 kV and above) system from the previous year. For calculating the zone wise distribution losses
total billed energy in the State (as per accounts) has been divided, in the ratio of previous years zone wise billed energy. The percentage technical losses in each zone have also been assumed to be same as the previous year.

Based on the above assumptions the total T&D losses and the agricultural consumption corresponding to the year 2001-02 has been estimated and is given in the following table 4.17.

The following table gives summary of distribution losses (11 kV and below network) at two different base 1. Input at distribution level i.e. 11 kV input and other 2. Is input to the state. The total energy loss and its segregation in to technical and non-technical losses (Percentage) for the base year 2000-01 for the North, Central, South, west 1 and west 2 zones has been given.

Table 4.16 Summary of Distribution losses (11 kV and below) and Agricultural Consumption during 2000 -01

	Total Technical Energy loss	Total Commercial energy loss	Total Energy Loss	Total Technical Energy loss	Total Commercial energy loss	Total Energy Loss	Total Agricultur Consumpt MU
Base	*Total 11 kV input in the Zone*			*Total State input*			
Zone							
North	8%	4.9%	13%	2.0%	1.2%	3.2%	6647
Central	8.9%	25.1%	34%	0.9%	2.5%	3.4%	925
South	6.9%	60.5%	67.4%	1.0%	8.8%	9.8%	919
West - I	5.3%	29.8%	35%	0.8%	4.7%	5.5%	2465
West -II	2.8%	22.1%	25%	0.3%	2.4%	2.7%	1881
Total State) (LT Network Losses)				5.0%	19.6%	24.6%	12837
			Total T&D Losses in GEB System				
Total T&D Losses GEB				8.3 %	20.5%	28.8%	12837

The following table gives summary of distribution losses (11 kV and below network) at two different base 1. Input at distribution level i.e. 11 kV input and other 2. Is input to the state. The total energy loss and its segregation in to technical and non-technical losses (Percentage) for the base year 2001-02 for the North, Central, South, west 1 and west 2 zones has been given.

Table 4.17 Summary of Distribution losses (11 kV and below) and Agricultural Consumption during 2001 -02

	Total Technical Energy loss	Total Commercial energy loss	Total Energy Loss	Total Technical Energy loss	Total Commercial energy loss	Total Energy Loss	Total Agricultural Consumption MU
Base	*Total 11 kV Input in the Zone*			*Total State input*			
Zone							
North	7.5%	0.1%	7.6%	1.3%	0.5%	1.8%	6910
Central	8.9%	24.5%	33.4%	0.9%	2.4%	3.2%	962
South	6.9%	68.8%	75.7%	1.0%	10.2%	11.3%	956
West - I	5.3%	32.3%	37.6%	0.9%	5.2%	6.1%	2563
West -II	2.8%	18.8%	21.6%	0.3%	1.9%	2.2%	1955
Total State) (LT Network Losses)				4.4%	20.2%	24.6	13345
			Total T&D Losses in GEB System				
Total T&D Losses				7.7%	21.1%	28.8%	13345

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Issues and concerns

The T&D loss estimation study undertaken by TERI has opened up various issues related mainly to areas in Distribution System Management and other managerial activities prevalent at various levels in GEB,. We have classified the various observation/issues involved both at technical and managerial aspects in GEB as follows.

Data Management

Availability of correct data was found to be one of the major constraints during the study. Information flow in Gujarat Electricity Board is upward and hardly any cross checking is done at higher level to validate the data submitted by the lower offices.

EHT network

1. Maintenance of data and its compilation of various hourly parameters such as energy sent and received Ampere, voltage at various substations is on logsheets and this provide ample opportunity to manipulate the same.
2. Calibration of panel meters is not regularly carried out which results in mismatch between energy sent and energy received.

Distribution System (11 kV and below)

1. Transformer wise and category wise number of consumers connected and their connected load is not maintained at one place.
2. The data available with circle offices does not match with the data available with divisional or sub-divisional offices. This poses a biggest challenge to carry out energy audit.
3. Data about the network status etc needs updating at various places and especially the sketch of 400 V network between the transformer and the consumer end is not available in most of the sub divisions, which is a prerequisite. for realistic loss estimation studies.

System Planning and Maintenance

Distribution System

Presently GEB have system of planning its network based not theoretical calculation and various decisions such as feeder expansion, bifurcation, up gradation, reconductoring is made on judgment basis instead of carrying out Load Flow Studies on the computers. Transformers installed are of old technology, which again contributes in high technical losses. At some places, transformers were found to be overloaded.

Metering and Billing

Field visit to various substations suggest that the meters have been installed only up to the sending end of 11 kV feeders. The following observations were made
EHT System

1. Almost all the panel meters installed at the various points are electromechanical type with very high CT/PT ratio and multiplying factor. This increases the errors in recording the consumption
2. Most of the meters are old and needs calibration. Faulty meters again introduce the error in electrical parameters recorded.
3. At few substation length of CT leads are very large which contributes to higher losses.

Distribution Systems

1. The Meters have not been provided at the LT Side of the Distribution Transforms, which is a prerequisite for carrying out proper energy audit. to identify high loss areas.
2. Presently the billing process in GEB is subdivision wise, and there is a significant time gap between the meter readings of adjacent consumer. on the same feeder. This introduces the error in the energy accounting in the absence of reliable data.
3. At some locations the Digital Meters installed by GEB at the LT side of DT's located on the identified feeders could not be kept in working conditions due to improper installation of these Meters. resulting in incorrect measurements.

Technical Losses

Technical losses in the GEB system are generally not very high except at few feeders except in the North Zone, the LT/HT ratio is very high

Commercial Losses

1. Commercial losses in GEB system are very high especially in South ,Central and West Zones In South Zone commercial losses are around 60 % .In West Zone these losses are of the order of about 30 % whereas in Central zone these losses are of the order of about 25 % These commercial which are mainly due to poor metering, theft/pilferage ,less effective vigilance system. GEB have been incurring heavy revenue losses due to these commercial losses. Tackling the problem of commercial losses may be difficult but not impossible and needs a strong will to do that. Available data suggest that a large percentage of meters are faulty and direct hooking at 11 kV voltage level is also prevalent in West Zone.

Connected Load

During the visit to various consumer premises and the subdivision offices, TERI team observed the following

1. The updated data about the connected load of various consumer categories is not available especially the connected load in domestic category of consumers is not available at one place.
2. In the North Zone it was generally observed that agricultural consumers are operating on a load higher then the sanctioned load. This was the further supported by the MRI readings of the digital meters. In the sample size identified in North zone actual connected load were almost 12 % higher then the sanctioned load.
3. At many places in North zone, consumers were found to be operating during the two-phase supply with the help of suitable capacitors.
4. Similarly in the West zone the consumers were also are operating at a higher load than the sanctioned load
5. At most of the identified feeders in West Zone, the losses in the HT feeder (11 kV), are comparatively high (varying from 2% to 26%). One of the reasons for this could be attributed to pilferage and theft by direct hooking of 11 kV feeders.

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Conclusion and Recommendations

General

1. As it is evident from the results that the total **technical losses** in the EHT(66kV and above) System(2.9 %) as well as in the Distribution (22kV and below) System (5%)are within the limits set out in the guidelines issued by Central Electricity Authority in 1992
2. The Commercial Losses in the EHT System (1.3%) can only be attributed to Metering Error / Data Recording Error. The chances of Pilferage or Theft at EHT level are remote
3. It is observed that high level of commercial losses in the Distribution System is mainly attributed to cases like sample. Given the time and financial constraints, a large sample size at the LT level could not be considered. It is however desirable that the sample size of the LT network should be more broad based.
4. It is clearly evident from the results that the commercial losses in the LT system make the overall GEB losses high. However, unless this problem is tackled by launching special anti-pilferage and anti-theft drive in the theft prone areas especially in South and West Zones, it would be difficult to bring down the overall losses to an acceptable limit. We appreciate that this involves major socio - political norms and unless the Utility is armed with the appropriate legislative powers and aided by the State Administration containment of pilferage is difficult since the illegal hooking, if removed in a day, would once again reappear the very next day. The culprit has to be booked. Unless strong actions are taken against such offences, the problem will remain.
5. We understand that that GEB is already in the process of intensifying activities of the vigilance squads. It should be given priority and stepped up further.
6. Innovative loss reduction measures such as Incentive Award Scheme" may be tried.
7. Under this scheme an employee who brought to light cases of pilferage of energy is rewarded on the basis of the recovery made from the customer.
8. Severe penalties may be imposed for tampering with the meter seals etc.

9. Energy audit should be introduced and personal responsibility should be fixed on the concerned officials for energy received and energy sold in each area.
10. In case of South & West Zones, it is observed from the field visits that the Over Head bare conductor Distribution lines are tapped to supply electricity. In such theft prone areas, it is suggested to convert OH lines to underground cables/OH bunched cables, which will a large extent reduce the chances of placing hooks directly on the bare live OH conductors. The conversion should be done in a phased manner for all such theft prone areas.
11. Launch public awareness campaigns highlighting illegality of the pilferage/theft at the same time giving tips on how to conserve electricity consumption.

Data Management

Data management is the backbone for every activity in a utility, its importance is widely known and can not be ignored. However data management in GEB requires a change

Recommendation:

In order to have a proper, efficient and easily extractable data for analysis the following recommendations are made:

1. GEB should maintain the data relating to the consumers and their connected load. category wise , transformer wise and feeder wise
2. GEB should up date the data on the various parameters including the LT sketch of 400-volt line network emanating from Distribution. Transformers located on various feeders in order to avoid the data mismatch at various levels and to have reliable level of data accuracy
3. GEB should adopt the computerized on line MIS system. Where all the divisional computers are connected with WAN and information fed at divisional level is directly available at Head office. This change can not be carried out for such a large system at one go, hence this should be done in a phased manner and in the mean time computerized data transfer at various level has to be carried manually. In a longer time frame GEB should aim at a **fully computerized on line data management system.**

System Planning and Maintenance

1. GEB should create a **separate** planning wing for micro **level Distribution planning** at each circle level. The planning wing should have adequate facility in terms of software, computer support and accurate data about the network and load growth.
2. Persons in planning wing should have adequate knowledge / background of Distribution Planning and they must be fully involved in all aspects of the planning process

Metering and Billing

Metering is the most important aspect of any utility for efficient working, The billing process must be efficient and consumers friendly. All billing details should be available in bill.

Recommendations

1. GEB should replace **the electromechanical Panel meters** especially meters having high CT/PT ratio **with** high precision **Digital Meters** and low multiplying factor in a phased manner.
2. **The Core Group** created to carry out Energy Audit may also look into the issues related to metering such as calibration & testing of meters, replacement of meters and proper maintenance of Meters.
3. GEB should install the high **precision Digital Meters** in phased manner on the all distribution transformers located on **high loss feeders**
4. GEB should make it mandatory to have **Digital Meters** for all new connections.
5. GEB should initiate the billing of the consumers' feeder wise. A person at JE Level could be made responsible for taking care of the billing process feeder wise.

Technical Losses

Technical losses in the GEB system are not very high. Only a few feeders were found to be having very **high technical losses.**
The LT/HT ratio was found to **be high as** compared to the ideal ratio of 1:1 in all the zones of the State **except for North Zone.**

Recommendations

1. Replace the **overloaded existing transformers** with **amorphous core type**
2. Based on preliminary studies **redistribution of load** among various feeders in high loss areas be initiated.
3. The LT length of feeders should be **minimised** to the extent it is technically feasible.
4. **Capacitors** at suitable places be installed in order to have better voltage profile in the system.

Connected Load

During the field Visits to different consumers premises and the subdivision offices, the following observations were made.

Recommendation

GEB in a phased manner and after framing the appropriate strategy should recheck the connected load of consumer especially for the agricultural consumers where tariff is based on the HP.

Generic recommendations

It is suggested that the above suggestions be implemented first in a small area as **a pilot project** to demonstrate the impact of these suggestions. This could be initiated with area catered by say one substation only and the viability and cost benefit analysis can be carried out of such exercise. This can further be implemented over large area in a phased manner.